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CONTENTS

PROBLEMS WITH COAL LIQUEFACTION, GASIFICATION PLANS

Duesseldorf WIRTSCHAFTSWOCHE in German 7 Mar 80 pp 18-21

> [Text] Coal liquefaction and gasification are to decrease the FRG's dependence on oil. Yet environmentalists are mobilizing. And besides, it is questionable whether there is sufficient domestic coal.

Environmentalists on the Rhine and Ruhr Rivers were jolted by a somber news report. The air in South Africa's industrial regions is being so severely polluted by the start of operation of coal upgrading plants that the sparrows are dropping from the sky. Although the assertion turned out to be untrue--the misgivings of the environmentalists have remained. The protests against the 14 big projects for coal upgrading are growing increasingly louder; these were being promoted by Minister for Research Volker Hauff with DM70 million (see Table).

Starting in 1984, 11 coal gasification plants and 3 coal liquefaction plants are to be put into operation at an investment cost of about DM13 billion. At the International Environmental Protection Fair Envitec in Duesseldorf in February, Chancellor Helmut Schmidt demanded that seven of these plants be built in the Rhine-Ruhr district. However, air pollution in this region is already extraordinarily high.

Even Volker Hauff concedes that a liquefaction plant with coal consumption of 5 to 6 million tons of hard coal each year will cause as much dust and noise as a modern coal power plant with three standard blocks. In addition, there are also the disagreeable waste gases and waste water similar to a modern large refinery.

The controversial project is being planned by Veba AG [United Electricity and Mining Corporation]. A plant for obtaining gasoline and heating oil from coal and extremely heavy oil is to be built at a cost of DM4 billion on the bend of the Rhine River near Orsoy.

Whether the large plant can ever be built is still questionable. At the beginning of the 1970's the citizens and city fathers of Duisburg successfully resisted construction of a refinery on Veba's own land. The mood is

no different today. Duisburg environmental protection organizations are warning the "friends of Veba" on the council and in the administration that "citizen initiatives with mobilization actions will be able to prevent such attacks on the health and well-being of the citizens. The necessary preparations in terms of personnel and organization have already been made."

Even the SPD politicians who are in control in the city council are critically opposed to the project. The opposition of SPD municipal politicians along the Rhine and Ruhr caused the chancellor to warn his party comrades publicly of a "church tower policy": "In view of the energy policy problems, environmental protection in the Ruhr district cannot continue as the supreme law of life." Anyone who says "priority for coal" must also say that this will result in more environmental pollution.

How severely the environment is being damaged is being vigorously disputed. Thus, Prof Werner Peters, business manager of Mining Research, Essen, does not consider the planned large upgrading plants to be very harmful to the environment. Peters says: "Eliminating pollutants is far more difficult in power plants than in gasification and hydrogenation plants. Mining industry research, on the other hand, sees far more difficulties in the search for a site.

Thus, the North Rhine-Westphalian "decree on distance" states that the distance between industrial plants and residential areas must be 1.5 km. The space requirements for upgrading plants, however, which require an area of 4 square km, are two to three times as great as those of comparable coal power plants.

Yet not only the question of site, but also an adequate supply of coal for the upgrading plants is unclear. The Rhine Brown Coal Works AG in Cologne can scarcely increase its output. Damage to the enviornment by the five coal pits which are being strip-mined has reached the acceptable limit. Brown coal, which would be made available for upgrading, would not be available for supplying electricity and could only be replaced by nuclear power.

Times are by no means rosy for hard coal either. Ulrich Steger, SPD Bundestag delegate who is well-versed in energy questions, also gives an emphatic warning about "coal euphoria." Some 20, perhaps even 30 million tons of today's mining capacity will be exhausted next year and must be replaced. The new collieries, however, are, without exception, in recreation areas in the immediate vicinity of the Ruhr district. In addition, in the next 10 years alone, hard coal mining will lose approximately 60 percent of its German employees and almost 80 percent of the technical skilled workers because of age. They could only be replaced by foreign guest workers which will cause new, unsolvable problems.

Up to the year 2000 mining capacity for German hard coal might thus be increased in any case from today's approximately 80 million tons to 100 million tons. The demand for upgrading coal will be just enough to supply the demonstration projects which have been announced.

Not only for this reason does Fritz Oschmann, chairman of the board of Veba Oil AG, plead for the building of hydrogenation plants where there is cheap coal. Oschmann's reckoning is simple: coal would have to be imported for large scale hydrogenation.

Since roughly 3 tons of hard coal (10 tons of brown coal) are consumed for a barrel of coal oil, 3 times that much (10 times) must be transported in connection with hydrogenation in the FRG.

Against this background, energy expert steger likewise warns against thinking that gasoline from coal is cheap. According to his calculations, a liter of coal gasoline will cost DM2.30. Steger's sum total opinion: "Euphoric expectations are just as harmful as false alternatives."

Focal Point in the Ruhr District: Projects and Processes for Upgrading Coal in the FRG

Company	Technical Process	Location	Start of Operation	Starting Quantity and Raw Materials (in millions of annual tons)
Ruhr Coal/Ruhr Chemistry	Texaco Gasification	Oberhausen-Holten	1984	0.40 German hard coal
Ruhr Coal/Ruhr Gas	Lurgi Pressure Gasification	Ruhr District	1984	3.0 German hard coal
Rheinbraun	High temperature Winkler process Fluid catalyst process	Berrenrath	1984	2.25 crude brown coal
Shell	Shell-Koppers Gasification	Undecided	1984	0.30 hard coal
Flick	Fasthett Gasification	Hueckelhoven	1985	0.50 hard coal
Korf	Otto Gasification	Undecided	1985	0.10 hard coal
Saar Mines	Otto Gasification	Saarland	1985	0.40 German hard coal
Texaco	Texaco Gasification	Moers-Meerbeck	1985	0.36 hard coal

Focal Point in the Ruhr District: Projects and Processes for Upgrading Coal in the FRG (Continued)

Company	Technical Process	Location	Start of Operation	Starting Quantity and Raw Materials (in millions of annual tons)
VEW	Partial Gasification	Emsland/Lippe	1985	1.80 hard coal
Ruhr Coal	Modified IG liqueifaction	Ruhr District	1986	6.0 hard coal
Thyssen Gas	Fluid catalyst process gasification	Oberhausen-Holten	1986	0.35 hard coal
Veba Oil	Modified IG liqueifaction	Orsoy or North Sea coast	1987	6.0 hard coal or heavy oil
Saar Mines	Modified IG liqueifaction	Saarland	1987	2.0 Saarland flame coal
Rheinbraun	Hydrogenating coal gasification	Rhineland brown coal district	1990	5.0 raw brown coal
Rheinbraun	Modified IG liqueifaction	Rhineland brown coal district	1992	3.5 raw brown coal

Ruhr Coal and Veba are negotiating with the goal of joint direction of the projects.
Source: Ministry for Research and Technology

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NEW DIRECTION IN AIR TRANSPORT POLICY NOTED

Paris LE MONDE in French 16 Apr 80 p 19

[Article by Jacques de Barrin]

[Text] Minister of Transport Joel Le Theule, in his talk before the AJPAE [Professional Aeronautics and Space Journalists Association] Monday 14 April, spoke at some length on the "liberalization" of charter traffic from France and on the future of the regional companies.

Concorde Operations

Air France, which already operates five Concordes, one of which is leased, will add to its supersonic fleet, between now and the end of this year, two units that have not yet found buyers. "These two planes," Mr Le Thoule confirmed, will be sold to Air France for the symbolic one franc."

With the sixth Concorde, which is to be delivered immediately, our national airline plans to boost up its services on the Paris-New York route. On the other hand, it plans to reduce service on the Paris-Washington route, taking into account the fact that the American airline Braniff International has abandoned its plan to operate the supersonic jet between Dallas and Washington beginning 1 June, owing to the sharp increase in the price of kerosene and the low passenger-load coefficient.

The Air France Public Enterprise Agreement

The first public enterprise agreement signed between Air France and the state, the duration of which was 3 years, expires at the end of this year. A second agreement is to be signed, "the content of which will be very succint," Mr Le Theule said.

The management of the national airline have already made it known that they do not plan to seek government aid for their subsonic operations. On the other hand, under the new agreement on the Concorde, with effect from 1981, they seek "full coverage" by the state for the costs of operation, financing, repayments and loans.

Agreement Between the State and Air Inter

The agreement between the state and Air Inter "relative to the operation of domestic lines," which went into effect on 1 January [as published], will expire 31 December 1980. The government gave advance notice of termination 30 June 1979. "Inasmuch as the domestic company does not seem to be seeking a new agreement, probably no new agreement will be negotiated," Mr Le Theule said.

Is Air Inter incurring unjustifiable risks in refusing the "protection" of an agreement? "The domestic airline's business can certainly not be allowed to flounder," the minister insisted, "especially since it will have to carry the burden of putting into service the high-speed train between Paris and Lyon in October 1983." In regard to the opening of new routes, the government intends to adopt a pragmatic approach, deciding its position on a "case by case" basis.

The Future of the Regional Companies

The president of TAT [Touraine Air Transport] had sought a concession from the government granting TAT long-term traffic rights and an agreement stipulating the obligations of the two partners. This would have solidified the credibility of the domestic airline with its shareholders and its bankers. "The state is not prepared to enter into this type of undertaking," said Mr Le Theule, who is fearful of the consequences of such an approach.

"My position has changed," the minister admitted. "In the beginning, I felt the state should provide the impetus in this domain. Today, I believe the initiative must belong to the interested parties themselves and that the government must not serve as a substitute for anyone."

'Liberalization' of Charter Traffic

For a long time, the nonscheduled airlines have been coming up against the protectionism of the French authorities. "This situation could not continue," admitted Mr Le Theule, who recently "liberalized" charter flights to African points and particularly to Senegal (LE MONDE 3 April).

Have hopes been dashed by the policy about-face on the part of the Senegalese authorities that has just interrupted the "chain" of charter flights Nouvelles Frontieres had begun to operate between Paris and Dakar? "This attitude is not that of the entire African continent," the minister said. "Mr Felix Houphouet-Boigny, president of the Ivory Coast, and the Togolese minister of transport have recently communicated to me their desire to see charter traffic grow to satisfy the demands of tourism."

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DEVELOPMENT OF AUTOMATION IN FIAT BODY PLANTS

Turin ATA in Italian 2/80 pp 63-68

[Article by Engineer Walter Vignale, Fiat Auto S.p.A., GVF Body Technology Division]

[Text] The subject matter discussed in this paper is representative of some of Fiat Auto's most significant technological accomplishments.

They have to do specifically with the fabrication of automotive vehicle bodies, with the processes, that is, which probably cause the biggest problems to the company, partly because of the concentration of union actions in this sector, and partly because of the immediacy of interaction of this sector with market phenomena.

In the body manufacturing sector, from a chronological standpoint and generally speaking, we could say that Fiat has gradually evolved as follows:

Prior to 1968, the objectives being pursued were related to elimination, through automation, of production processes that were hazardous or injurious to health, taking advantage of the opportunities for economies of scale inherent in a situation of constant increases in production.

Between 1968 and 1973, the technological development effort was pursued, taking into account the demands of labor ensuing from union opposition, but nevertheless seeking to continue producing in the face of the persistent conflictual factor.

From 1973 to the present, to meet market saturation conditions of uncertain duration and characterized by sudden qualitative and quantitative changes in demand, and to recover some of the margins of flexibility lost as a result of labor disputes, technological innovations have been introduced whose applicability had been recognized.

Today, at the threshold of the 1980's, the rigid type of assembly line furnishing an identical product for many years is gradually being replaced by a type having a very high degree of flexibility, wherein each assembly-

line unit (for example, each shop) can furnish different components to different assembly-line units downstream, in accordance with quantitative programs and variable qualitative mixes with respect to time within conveniently ample limits. Moreover, production tooling is being designed with characteristics that are more easily modifiable for future models.

The body fabrication process can be differentiated into three distinct phases according to general types of work involved and their characteristic environments: steel bodywork, body paintwork, and body assembly work.

We shall discuss each of these phases in more detail.

Steel Bodywork

Until 1960-1965 and throughout the world, all welding, which is the prevailing operation in steel bodywork, was done manually, clamping the individual parts to be welded in specifically designed jigs. These jigs were either fixed in place on the shop floor or made movable along a line, depending on the required hourly production rate and hence on the extent to which the operation had to be subdivided among additional workers.

Subassemblies were then brought together for welding inside a large three-dimensional final-assembly box, called the "big box."

Mechanization and conveyors for transporting the heavier subassemblies and components were not lacking; but all spot welding was done manually, requiring considerable effort to manipulate the welding clamps, suspended and although balanced, as they were, to facilitate vertical displacement.

The environment was not the most agreeable. The overhead conveyors and hanging welding transformers prevented natural light from reaching the work-position, and the noise level was high owing to handling of the sheet-metal, the intermittent opening and closing of the clamps and the continuous movement of the conveyor chains.

In 1961, while retooling for the new 1300- and 1500-model cars, automated welding was introduced on the main body-subassembly: the car and luggage compartment floor, complete with lateral housings, transmission-axle tunnel, cross bracing, and mounting brackets for mechanical components and assemblies.

These cars were produced using an assembly-line technique modeled on the automated work-transfer principle, with a certain number of multiple-welding stations, a loading station and an unloading station, mechanized movement from one station to another, and mechanized clamping of components at each station.

Human labor was involved only in positioning the individual component parts on the loading station, and no longer in welding.

The demand for qualified maintenance personnel increased.

The automated work-transfer machine produced a better and more uniform quality, at least in this important subassembly of the body.

The main problem, which quickly made itself felt, with this type of machine was its inflexibility.

Awareness of this problem notwithstanding, however, the design concepts of this first work-transfer machine were extended and amplified in successive retoolings for the 124, 128 and 127 models. Not only the floor, but also the entire chassis, the body sides, roof and doors were fabricated entirely on multiple-weld work-transfer machines.

Manual labor was freed of most of the preparatory welding work involved in forming the body as a closed three-dimensional entity. But the problem of the inflexibility of these machines intensified: The welding machines were specific, each confined to a given body model, and any change in that body entailed long production stoppages for modifications to the machine. Furthermore, when production of that model was discontinued, very little of that machine, if any, was reusable.

The "big box" remained the traditional one, with four or five specialized workers to clamp the subassembly components in their correct relative positions, then baste them together manually by means of tack welds.

This technological situation prevailed until the end of the 1960's, while the labor union movement in progress at the time addressed, among other issues, also those of work rationalization, monotony and environment.

In 1972, the Cassino plant was retooled to produce the 126. The mechanization of steel bodywork was extended to the "big box," which no longer handled solely the tack welding phase but almost the entire welding operation.

This achieved the twofold objective of saving manual labor from having to perform another of the more burdensome operations, and of obtaining greater geometrical uniformity from one body to the next, thus preparing the way for the closer tolerances needed to properly automate the completion of welding after the tack welding phase.

The 126 automated "big box" had its faults. It was a congested and complex machine; too many transformers and electrodes were concentrated in its two stations; maintenance itself was a problem because of the time involved, requiring a total shutdown of the assembly line every time it had to be undertaken.

The requirement for intermediate processing establishments became apparent once again.

In 1972, Cassino adopted the model 126 "big box" and, concurrently, Mirafiori experimented for the first time with robots, in groups of 16, for completing the welding of model 132 bodies after having been tack welded manually in the traditional "big box."

The year 1974 saw model 131 tooling duplicated at Mirafiori and Cassino with some minor variations dictated by their different productive potentials.

This was a decidedly important stage in the development process, not only as regards the machinery involved, but also as regards plant layout, and had a substantial impact on work management.

Machines were surrounded by decidedly more ample space, lighting was improved and ambient noise was reduced.

The "big box" was distributed over two stations--and we had the start of polyvalence (or flexibility): at Mirafiori for production of the 4-door body and the 2-door body in random sequence, and at Cassino for the 4-door and "family" models.

The robots, 23 of them, were put into operation with no further qualms regarding their efficiency after 2 years of positive experience with them on the 132.

The conveyor that transferred the bodies through the "big box" and robot stages included a highly significant innovation for the quality and uniformity of the finished product: the pallet.

Each body was completely clamped at the start and kept clamped throughout the entire welding process, instead of being clamped and unclamped at each station. This eliminated the distortions produced in the bodies by coercion of the partially welded metal during clamping.

By 1978, the experience gained with the welding robots, the palletization of the entire body, the Robocarrier and the processing calculators made it possible to build a steel bodywork plant responding to an entirely new concept. It was given the name of Robogate.

We shall describe the operation of this plant in more detail later.

Paintwork

The first objective sought in this sector was the elimination of work stations that represent health hazards.

During manual spraying operations, if the cabin is not sufficiently ventilated--and in the older plants it was not--the workers are exposed to the inhalation of solvents and must therefore wear protective masks over mouth and nose while working. Fiat had been trying to mechanize the spray-painting process since the 1960's, and finally succeeded, mainly as regards the undercoating, concurrently with the adoption of the electrostatic system of spraying. It was, however, an inflexible mechanization, in that it was closely tied to a specific type of body and would simply not accept other types during the same run.

In cooperation with various outside manufacturers, robots were developed that enabled flexible automation of the spraying process, electrostatic as well as other.

These robots are controllable not only point-to-point, as in the case of the welding robots, but also continuously over a trajectory. They are equipped with an anthropomorphic arm that duplicates the human shoulder-elbow-wrist articulation, and their movements-program is automatically switchable instantly upon recognition, also automatically sensed, of the type of body presented for painting.

They also change colors from body to body, eliminating the erstwhile constraint of having to paint bodies in batches of the same color.

During 1977, robots of this type made by different builders were tested for automation of the spraying of body-interiors and door-rabbets at Cassino, and interiors and exteriors at Rivalta.

Following the successes achieved with these installations at Cassino and Rivalta, specific and flexible installations are now in the design stage for extension of the process to the various establishments. These installations will automate the underbody antirumble spraying process as well, replacing a particularly onerous overhead manual operation that must be done with raised arms and upturned eyes.

A noteworthy innovation in the technology of paintwork was introduced at the Termini Imerese plant (Palermo) with the putting into operation of the first installation for applying the undercoat in the form of powders.

The 126 was absolutely the first in Europe, and one of the very first in the world to have been produced with the entire body painted in this manner.

After several years of successful production experience with "powder-painting" of wheels (plants in the Naples establishment), and after a few years of testing with a pilot plant for painting entire bodies in this manner, the use of this technology was extended to the production of the entire body--production, that is, at the rate of 500 units a day--with obvious ecological advantages stemming from the fact that solvents are no longer used, and with advantages from the standpoint of quality.

Assembly

Final assembly is the area that least lends itself to automation owing to the practical problems of fitting that it entails.

Although an automated assembly technique that operates on the dimensions of the components and the bodywork tolerances is lacking, at least for the moment (in terms of fitting seats, wheels, radiator, fuel tank, windows, ...), it is in this area of final assembly that Fiat has achieved one of the most significant examples of automation: the automated bodywork of the model 131, on which I shall dwell in more detail later.

The following is a chronological summary of the fundamental stages in the evolution of bodywork automation:

1960--Multiple welding of steel bodywork on the 1300 and 1500 models, later extended gradually to all bodywork establishments.

1972--Automated "big box" for body-welding of the model 126 at Cassino.

1973--Welding robots on model 132, at Mirafiori, for completion of body welding after basting.

1975--Completely automated assembly line for body-floors, chassis and body subassemblies, with completion by means of robot welding, on model 131, at Mirafiori.

1976--Digitron equipment for automatic bolting of mechanical subassemblies to the body of the model 131, at Mirafiori.

--Automatic spraying of antirumble paint on underbody and lateral fascia boards, being extended to all other establishments.

1977--Application of undercoat by the system of powders, using automated and robot equipment, on model 126 at Termini Imerese.

1978--Robogate plant for robot welding of body and sides on the Ritmo model (Rivalta and Cassino).

--Automated body paint line utilizing robots and exterior-paint machines (Rivalta and Cassino).

--Automated plant for painting of body exteriors on model 126 at Termini Imerese.

We shall now discuss in more detail two particularly significant plants from the viewpoint of technological evolution, respectively in the areas of assembly and sheet metalworking.

Fitting of Mechanical Components to the Body

The plant for preparing and fitting mechanical components to the body of the model 131 was installed at Mirafiori.

The main elements characterizing the plant as a whole are the use of automatic bolting equipment and the particular system of material-handling.

The automatic bolting equipment has replaced the traditional line (called the "tow-veyor") consisting of a manual chain-operated conveyor and manual bolting of mechanical components to the underbody.

The material-handling system is characterized by the use of battery-powered electric trolleys called Robocarriers.

The Robocarriers are piloted by an electronic calculator, and their movements are guided by the electromagnetic field generated by radio-frequency currents; these currents traverse a complex network of cables buried in the floor.

This cable network conforms to the possible routes the Robocarrier can take in transporting its load to the various stations involved in the operations being performed.

The sequence of the main operations is as follows:

a) The Robocarrier with its pallet empty moves to the mechanical subassemblies loading zone, in accordance with a sequence of approach instructions received from a remote teletypewriter. The motor arrives suspended by a double-track aerial conveyor and is lowered directly on to the pallet by means of a hoist. The drive shaft, differential, suspension, exhaust and muffler subsystems, as well as minor components are taken from bins manually and placed on the pallet with the aid of hoists.

b) The Robocarrier proceeds to one of the 12 preparatory stations. A work crew (four workers) prepares the mechanical components, fitting the various subassemblies together by means of bolts (average time about 14 minutes).

c) At an electrical signal activated by the workers, the Robocarrier starts up again and proceeds to the prepared-pallet warehouse, where it gives up its pallet to the warehouse and receives another pallet containing the mechanical variant corresponding to the body that is at that moment arriving in the fitting area.

d) The Robocarrier coming from the warehouse with the pallet of preselected mechanical components goes to the station preceding the bolting station, and arrives at one of its five fitting pergolas: precisely the one at which the body to which these components have been assigned is also arriving to meet it.

A hoist lifts the pallet and releases the Robocarrier.

Meanwhile, the workers at the bolting station, as soon as they are free of the preceding vehicle, insert the bolts into the tips of the vertical pneumatic bolt drivers, step down from the safety footboards and start up the cycle.

e) The pallet being held in suspension by the hoist moves over to the bolting station, descends and automatically centers itself by mating up with locating pegs in the station's fixed structure. The body descends next, and is guided and deposited over the remaining locating pegs in the station's fixed bolting jig. The automatic bolting equipment comes up, compresses the suspensions, fits the other mechanical components to the anchor holes provided in the floor section of the body, bolts them and tightens the bolts, delivering the proper predetermined torques.

f) The bolting equipment descends again to its idle position; the car, complete now with its mechanical components, moves together with the empty pallet to the third station of the pergola. [As published--cf. d) above].

Here, the car is again hooked up to the overhead conveyor and the empty pallet is returned to the Robocarrier, which can now resume its rounds.

The technical solutions provided by this installation result in some noteworthy advantages, to wit:

From the sociological standpoint:

--decoupling of preparation time from the assembly-line rhythm, while overcoming the problems of monotony and repetitiveness of jobs through the grouping of diverse operations;

--the regeneration of operations through teamwork; it engenders a greater sense of responsibility at the individual as well as group levels;

--elimination of the overhead, raised-arms bolting operation;

--improved ambient conditions as regards lighting and noise-reduction;

--reduction of accident risks (safety circuits on the Robocarrier designed to stop it immediately in the event of its encountering any obstacle).

From the technical standpoint:

--increased work throughput resulting from a reduction in transporting and waiting times; the Robocarriers can be varied in number and in speed to conform to the required rhythm of production;

--each installation is characterized by versatility of use and lends itself to retooling for the production of different models;

--greater system reliability, even to the extent of perfect interchangeability of the carriers.

The Robogate

The name Robogate has been given to a new type of plant--completely automated--operating in the sheet metalworking sector for the assembly of the body and the fabrication of body side panels.

The Robogate's most important innovation is this: Unlike the sheet metalworking systems in use until now, Robogate is characterized by substantial (one might in fact say, total) flexibility. It is actually capable of producing two different models at any one time and, above all, will require only partial retooling for the production of new models.

This is why it is termed a highly flexible system, in that it is designed (insofar as concerns its main components) to outlive the models it produces. It must be borne in mind that today, in all countries, automobile models (and especially bodies) are changing much more rapidly than in the past. Consumer tastes change and market demands must be met rapidly in order to beat the competition.

One of the objectives it was sought to achieve with the Robogate was the realization of a welding system that would no longer have to be dismantled each time a model was changed, needing only a readaptation of some of its components, within a reasonably short time and at relatively limited cost, to meet the requirements of the situation. Two Robogate-type systems were designed, based on the same general operating principles: one Robogate for the welding of side panels and one for the assembly of bodies.

Putting aside the fact that the side-panel plant differs in certain respects from the body-assembly plant, let us examine the basic components of the generic Robogate module, describing the machines comprising it and their individual functions.

The welding operations, as indicated above, are performed by robots organized in groups of from two to five robots each.

Each group comprises a welding station that looks like a welded steel parallelepidal bay, each of whose three spatial dimensions is about three times the corresponding one of the body it accommodates.

Each robot currently memorizes the two work programs to be executed according to whether the body (or side panel) entering the station is a 3-door or a 5-door type.

A Robogate module consists of several stations. Each station is comparable to a work island. This arrangement is necessitated by the fact that each station operates at a rhythm that must not be too closely synchronized with that of any upstream or downstream station.

This is made possible by the plant's internal components-handling system, based on the Robocarriers described above, in the case of the bodies as well as that of the side panels.

The calculator, among its other functions, regulates the Robocarrier traffic (there are approximately 25 Robocarriers in each plant) to ensure that all stations are correctly fed, avoiding trolley collisions and traffic jams, bringing the Robocarriers to a halt--when it becomes necessary-- at the many stopping points provided in the system, allowing them to proceed again as soon as the situation permits, and requiring them to implement any necessary instruction changes enroute. This all takes place in a maximum of silence, since--as has been mentioned--the trolleys are electrically-powered vehicles.

The bodies and the side panels, however, are not loaded directly on to the Robocarriers, but rather through the medium of an intermediate structure, the pallet, the function of which is to anchor and clamp the assembly it receives, in the correct position, for the duration of the sequence of operations to be performed at the various stations.

The pallet itself is positioned over fixed locating-studs mounted on the Robocarrier.

Referring now to the body, its components (chassis, side panels and roof) are held together rather securely by the pallet. However, before the start of welding, the four subassemblies (which were initially only clamped to each other) must now be perfectly fitted to each other geometrically. This is done by the so-called "little scales," that is, the pair of frames (mounted at the basting stations) equipped with clamps that automatically close around the body, enabling the welding robots to apply some 90 initial tack welds: those that begin to provide a certain rigidity to the body structure. These are the so-called basting welds.

At successive stations thereafter, where the presence of "little scales" is no longer needed, the necessary completion-welding operations are performed until conclusion of the work program involved.

The plant's basic materials-flow cycle starts at the loading station, where the components are automatically deposited on to an empty pallet that has been brought to that station by a Robocarrier.

The Robocarrier is then dispatched from one to the other of the successive stations depending on the model of body it is carrying.

Finally, the Robocarrier, the welding on its load having been completed, is sent to the unloading station, where a hoist automatically lifts the body off and starts it on its way to further operations. The trolley with its empty pallet can now start another cycle, returning again to the loading station.

The operations performed inside the plant, such as the welding done at any of the stations or the movements of the Robocarrier from one stopping point to the next, are governed by a number of local control systems, each of which handles just one certain type and one certain number of operations.

The coordination of all these local control units is centralized in a single, rather potent, calculator, which supervises everything that takes place in the Robogate module. It:

--programs the sequence of work operations,

--distributes the plant's resources,

--signals the start, monitors and checks the results of each operation, and

--records and updates continuously the system situation and various statistics regarding the plant's production and efficiency.

The performance of all these functions requires a vast flow, a continuous exchange, of electrical signals, that is, of data.

The calculator, by means of its terminals (teletypewriters and video units) communicates--in fact, practically dialogs--with the operations and maintenance personnel. The calculator thus sends and receives all needed information, above all, signaling the need, if any, for human intervention. The latter occurs only in case of malfunction of any of the plant's components, aside from the need to start up and end the activities of each shift and retrieve the production statistics.

Finally, it is of interest to note and stress the fact that, besides conventional controls, the system provides an extremely severe and impartial type of control--being an automatic control--which tests the quality of the weld performed at every point.

In case of a fault and hence of an inadequate test result, the point (or points) involved can be rewelded immediately.

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CSO: 3102

SOLAR ENERGY RESEARCH, GOVERNMENT FINANCING

Stockholm NY TEKNIK in Swedish 17 Jan 80 pp 16-17

[Article by Hans Werner and Ulf Bergmark]

[Text] The sun offers an abundance of energy that can warm our houses and be converted to electricity. But it is expensive to utilize solar energy and the technology must be improved. Still, most people agree that solar energy has a future.

Nature's Own Fusion Reactor

The natural fusion reactor, the sun, radiates enormous quantities of energy. Each square meter of Swedish soil receives from 870 (Kiruna) to 1,000 (Svalov) kWh per year. The difficulty in making use of this flood is, on the one hand, the low energy density and, on the other, the great seasonal variations.

The sun gives us a quantity of radiant energy at the earth's surface that, on the average for the entire year, corresponds to 100 to 130 W/m^2 in the southern half of Sweden.

This can be compared to around 300 W/m^2 in southern Egypt. Thus, conditions are good even in the cold and, during the winter, rather dark Nordic countries to utilize solar radiation.

But the great problem is to find economically and technically satisfactory methods for storing solar energy. It must be stored from day to night and from summer to winter.

Theoretically, more than half the radiant energy can be converted by photochemical methods. Intensive research is underway.

Closer at hand is the attempt to store energy in water and solid material (sand, mountains, concrete, etc). It is expected that in 1984 the Construction Research Council will present its answer to the question of whether it is possible to heat Swedish houses economically throughout the year using solar energy.

To meet the heating needs of small houses, completely new, chemical storage methods are certainly needed. This, too, is being developed.

Measurements Underway

To create a better basis for decisions, measurements are now being made at 12 stations in Sweden. This is a meteorological study of solar radiation.

The relatively low intensity means that the solar collectors must have large surfaces. Even simple collectors in the low temperature range, between 40 and 90 °C, can provide a good supplementary quantity of heat, at least in theory. It is precisely this temperature interval that includes around 40 percent of the Swedish energy consumption.

The most immediate use would be, like the Japanese, to warm tap water with solar heat. This technology is seen even today as very nearly profitable. For this and other similar purposes for producing additional heat, there are at least 17 various solar collectors on the market.

There are a total of at least 99 developmental projects underway in Sweden, of which 37 involve heating houses and 7 generating electricity.

Large State Subsidies

Most of the solar projects receive subsidies from the state. This occurs by way of the Construction Research Council (BFR), the Board for Technical Development (STU), and the Commission for Energy Production Research (NE). With regard to solar heating, the BFR administrates most of the state funds.

To find out by 1984 if home heating with solar energy is worth investing in, the BFR (and STU) is distributing during this fiscal year alone 82.7 million kronor in subsidies and 41 million kronor in loans. This applies to work with solar heating systems, energy storage and management, and heat pumps.

During the entire three year period from 1978 to 1981, 172 million kronor is being distributed via the BFR. This figure is expected to increase during the next three year period to 236 million kronor and, during a third three year period it will be 180 million kronor.

Five major directions are clearly indicated by BFR's current plan for rapid development in this area.

1. Solar heating centers for at least 500 apartments each. The heat is stored in water. The most limiting factor should be the surface area required for the solar collectors.

From 1978 to 1981, 35 million kronor is being invested, among other things, for a prototype in Studsvik and half-scale facilities in Vaxjo and Linkoping.

2. Storage in the ground. If these efforts are successful, they can be of greater significance than water storage. A total of 35 million kronor is going, among other things, to six half-scale facilities for deep-earth heating and one full-scale facility for surface heating.

3. Storage in bottom sediment in lakes and sea inlets. Tests of this should begin between 1981 and 1984. Preliminary studies have been made on what is planned to be five prototypes of heat exchangers connected to energy storage in sediment. This will cost 10 million kronor.

4. Chemical energy storage is a necessity if small houses are to be heated with solar heat throughout the year. The BFR is investing 10 million kronor in this area.

5. Solar heated tap water is clearly the dominant area for development during the first three year period. The area of tap water includes three prototypes and 70 full-scale facilities, supported by a total of 50 million kronor. After 1984, this procedure should no longer require state subsidies, the council believes.

Subsidies For Energy Production

The NE is responsible for other, no less important parts of the Swedish solar energy program. At present, 4 million kronor per year is involved in the following areas:

1. solar cells,

2. concentrating solar plants (in Spain), and

3. photochemical systems. The commission has entrusted this to a unique Swedish research group in Uppsala and Gothenburg.

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SWEDEN

PHOTOCHEMICAL PROCESS PRODUCES HYDROGEN GAS, ELECTRICITY

Stockholm NY TEKNIK in Swedish 20 Mar 80 pp 48-50

[Article by Hans Werner]

[Text] Many researchers consider hydrogen gas to be the fuel of the future. Hydrogen gas is pure and energy-rich. The only product from combustion is plain water. And plain water can also become the most important source of hydrogen gas in its pure form. As we know, water consists of hydrogen and oxygen. Up to now, the problem has been that it has not been possible to split the water molecule without using as much energy as the amount obtained from the hydrogen gas. Now this seems possible--with the help of additional energy from the sun.

The sun can produce both electricity and fuel. This is demonstrated by a photoelectrochemical cell that is being demonstrated by a research group of photochemists from Gothenburg and Uppsala.

In its simplest form, the small electrochemical cell consists of a light-sensitive electrode of n-doped titanium dioxide (TiO_2), which is a semi-conductor, and a platinum plate as the counter-electrode. The electrolyte is diluted sulfuric acid with a pH of around 1.

The TiO_2 electrode absorbs light. The experiment shows that hydrogen gas and oxygen gas are produced from a water solution at an electrolytic potential that is clearly lower under illumination than in the dark. Thus, the light promotes the splitting of the water molecule. This shows that sunlight can be exploited for the production of hydrogen gas. Photochemical storage of solar energy is possible.

The Chemistry of Light

"We should find out during the 1980's if this is a method that can be used on an industrial scale," says the group's leader, Prof Stig Claesson.

In the confused energy debate, everyone agrees on one thing: in the long run we must try to utilize the sun more and more as a source of energy.

During several decades, the Claesson Institute for Physical Chemistry has been built up so that it is now well suited to this type of research. It has to do with the chemical effects of light.

By a liberal estimate, there are no more than 200 specialists on earth in this boundary region between chemistry and physics. This number includes the Swedish research group. The Commission for Energy Production Research (NE) has noted this and is supporting the group.

Explosive Increase In Reports

Interest in the photochemical conversion and storage of solar energy increased dramatically in the early 1970's. The starting signal was, among other things, a Japanese discovery (by Honda and Fujishima) showing that water could be divided into hydrogen gas and oxygen gas by illuminating a titanium electrode in a photochemical cell in which the counter-electrode was immersed in sulfuric acid, while the titanium dioxide electrode was placed in sodium hydroxide.

The number of research reports and other scientific literature published annually in the field rose between 1970 and 1975 to more than ten times the average amount per year during the 1960's. This must also depend in part on the oil crisis.

Do we then, living in the cold and dark, during the winter, Nordic region, have the necessary conditions for heating our houses and running our motors with solar energy? The answer, according to Stig Claesson and his co-workers, is that conditions here are better than one might believe.

In a comparison, for example, with North Africa, one finds an incident radiation in the desert of 2,300 kWh per year and m^2, while in Svalov the corresponding figure is 1,000, in Stockholm 980, and in Kiruna 870 kWh per year and m^2. However, it should be remembered that in Sweden the incident light is diffuse.

Enormous Storage Problem

"Sweden has an enormous storage problem," Docent Bertil Holmstrom says. This applies to energy storage from day to night and from summer to winter.

He, together with laboratory engineer Per Carlsson in Gothenburg, has made the test cell in question (by Honda's method) with the remarkably effective heat-treated TiO_2 electrode and its potentiostat.

Unfortunately, titanium dioxide's absorption spectrum lies in the ultraviolet region of the spectrum. But with suitable dyes absorbed on the surface, the semiconductor-type electrode may possibly manage to provide us with photochemical solar energy storage on a really large scale, primarily in the form of hydrogen gas.

"So far, no system has been totally completed. But here in Uppsala we have the proper equipment to study, among other things, the excited state of dye molecules," says Dr Lars Tegner who, together with his colleague Docent Bengt Finnstrom, completes the quintet.

Search For Construction Material

Its immediate task is to investigate suitable dyes that may make it possible to utilize a larger portion of the spectrum than is the case with the laboratory model. This will probably be followed by a more fully developed prototype during 1980.

The titanium dioxide electrode has proven to resist photocorrosion. This is an ailment that otherwise occurs often with possible electrode material. This electrode was manufactured in Gothenburg by simply oxidizing a titanium plate in oxygen gas and subsequently inducing faults in the oxide layer by treatment with hydrogen gas.

The results indicate that industrial photoelectrolysis is a practical possibility, although this has not been conclusively proven. Now the immediate question for the group is if it can find an even better construction material.

In two internationally acclaimed publications--NE Project Results 1977:6 and 1979:2--they have compiled the world's knowledge of the photochemical conversion and storage of solar energy. Nature is able to store energy by photosynthesis, although with low efficiency. An additional disadvantage is that the carbohydrate product is not an ideal fuel.

Perhaps chemists will be able to make systems at least as effective to produce hydrogen gas and possibly hydrocarbons and other desirable energy-containing substances.

Long Conversion Period

It is well known that the energy-rich hydrogen gas is a fine fuel. The only product of proper combustion is water.

If, perhaps even during the 1980's, there should be an effort to convert to a hydrogen-based energy system, it would still take several decades to fully carry out the decision. The group of Swedish chemists is in complete agreement about this.

But even if it takes several decades to produce an energy system that is hydrogen-based to a significant degree, the solar method has an enormous advantage: if sunlight is converted to hydrogen, oxygen, and electricity (with water as the raw material), the earth's natural energy balance is not disturbed!

New Chemical Properties

The mechanism of a photochemical process is based on the principle that an excited molecule--i.e., a molecule in which applied light energy has moved an electron to a higher energy level--has a completely different electron configuration and, thus, completely different chemical properties.

The only possibility of storing light energy is if the photochemical reaction, as in natural photosynthesis, is energy-absorbing. The separation of water into hydrogen and oxygen is such a process.

So much for the thermodynamics of the cell in Uppsala. In the eyes of the semiconductor technician, the important thing about the TiO_2 electrode--which in this case is not a single crystal--is that it has typical semiconductor properties with a band gap of 3.06 eV. This is a measure of the difference between the electron's energy in the so-called valence band and the more energy-rich lowest level in the conduction band.

If the electrodes are connected with a wire, an electric current will flow. Its strength is directly proportional to the light intensity.

Heat Is Waste Product

There are, however, several limitations on this chain of events. As Lars Tegner states: Photon processes are superior to thermal absorption processes in that the light energy can be converted to a more valuable energy form (chemical or electrical) than heat alone. But a price must be paid for it.

Each photon process is characterized by a threshold wavelength. It represents the work required for the electron to be raised above the band gap of the semiconducting material.

No photon with a longer wavelength can be used in this process and all photons with shorter wavelengths contribute exactly the same energy as the threshold photon. All excess energy becomes waste in the form of heat, which, however, can be used in purely thermal processes.

Precharging Helps

The electrochemical cell now being studied in detail is actually a hybrid. It operates with both precharging and light. It is comparable to the Schottky barrier in semiconductor technology, in the junction between a semiconductor and a metal.

Part of the energy needed to produce hydrogen gas in water is obtained from precharging, which introduces whatever electronic energy is missing.

Here, researchers can now choose the threshold wavelength by applying the correct dye and a suitable coating thickness, in combination with the

proper semiconductor. Based on the free energy that has been obtained--which is 1.23 eV per electron in water photolysis--the theoretically estimated maximum efficiency is around 22 percent at a threshold wavelength of 680 nm.

This can be compared to photosynthesis, which in a leaf or in algae converts solar radiation to D-glucose at a maximum efficiency of around 9 percent. This, in turn, can be compared to the "ideal" value of around 13 percent at a threshold wavelength of 720 nm.

Analysis Quick As A Flash

In the late nineteenth century, chemists had already shown that the photoelectric effect, discovered by Becquerel, is enhanced in electrochemical systems if the electrodes are coated with a suitable dye. Using, among other things, flash photolysis and other advanced methods, the Uppsala group is now seeking the "right" dye.

One method for investigating the role of the dye molecules in electrode reactions is laser-pulse measurements with a duration of less than a nanosecond.

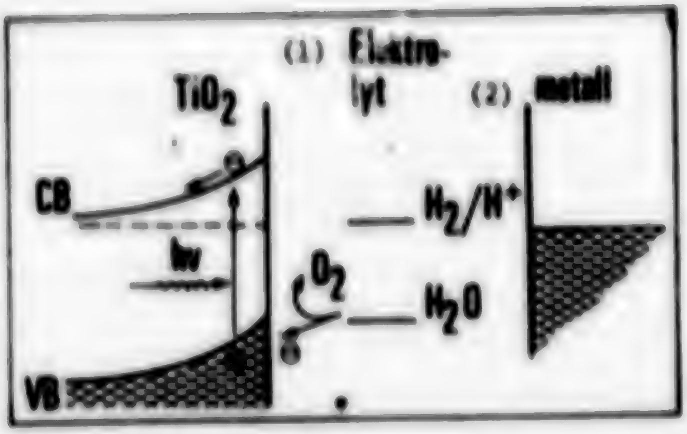
A new argon-ion laser for this purpose, among others, is presently being installed at the institute.

The details of what actually occurs in photochemical reactions is still an area in which researchers' maps reveal large blank spaces. In the test cell, for example, peroxide formation and other reactions can occur, which scientists must learn to understand and control. For this reason, it is a long step from laboratory tests to industrial utilization of the photo-supported electrolysis of water.

The problems of photochemical energy storage have been attracting more and more scientists since the two Japanese researchers Fumishima and Honda reported their discovery in 1971 of the photoelectric oxidation of water.

The Swedish group is now working with an electrode of the same material but not in single crystal form. This is more attractive with regard to possible future industrial production of electricity and gas.

Similar designs, but with other types of semiconductors, have already been patented in many parts of the world. The field is apparently well on the way to becoming of commercial interest.



KEY: (1) Electrolyte
(2) Metal

When a photon (hv) illuminates a semiconductor of, for example, rutile (TiO_2), an electron moves from the valence band (VB) up to the higher energy level of the conduction band (CB). When the circuit to the counter-electrode, a metal such as platinum, is closed a photocurrent passes through the wire. Water in the electrolyte is separated into hydrogen gas and oxygen gas. Four incident photons produce two molecules of hydrogen gas and one molecule of oxygen gas. In this way, photochemists can now produce both electricity and the fuel hydrogen gas. The latter has only water as a residual product with proper combustion.

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LOCAL HEATING IS ALTERNATE ENERGY PLAN FOR STOCKHOLM

Stockholm NY TEKNIK in Swedish 14 Feb 80 p 24

[Article by Rolf Myhrman]

[Text] Stockholm must not allow itself to be locked into the use of remote heating. Instead of remote heating, the Greater Stockholm area should invest in "local heating"--heating centers for 50 - 500 apartments.

"Local heating" provides the greatest opportunity for alternative heating, for example solar heating. This is one of the main points in the alternative energy plan for the Stockholm area, presented this week by the People's Campaign, Alternative 3.

The large metropolitan regions are the areas in Sweden that are most restricted to imported fuel and converting to alternative forms will take the longest. Peat, wood chips, or biomass are not for the large cities. The transportation distances are too great.

With regard to Greater Stockholm the current energy plan means a doubling of the remote heating network by 1990, with heat delivered either by tunnels from the Forsmark nuclear powerplant or from new coal-operated plants. This, the alternative energy plan maintains, is locking up the development. Remote heating systems have high fixed costs--powerplants, pipe systems, etc.

Alternatives such as solar heat and heat pumps cannot come in and compete. The "alternatives" must namely compete with the mobile part of the energy costs (fuel prices). Fixed costs are present even if the system is complemented by alternative heating.

However, the alternative plan does foresee some development in remote heating through 1990--but only about half as much as that provided by the current plan. As as an energy source for remote heating, the alternative plan would use LNG-natural gas via Nynashamn (the proposal is presented in greater detail in NY TEKNIK, 1979:20). Remote heating will answer for almost half the region's heating in 1990, as opposed to 30 percent today.

The alternative plan would cover almost 40 percent of the energy need during the 1990's with "local heating." The remainder consists of individual systems, primarily private houses.

Local heating centers, which are now usually called block or neighborhood h ating centers, are the easiest to adapt to new energy systems--primarily heat pumps and/or solar heat. Many of these local heating centers are already in existence. They are currently powered by oil.

A Size With Profitable Alternatives

"For heating systems of this size, research indicates good--profitable--alternative solutions," says engineer Kjell Wanselius, who worked out the alternative proposal.

"All the alternatives in the referendum claim to support alternative forms of heating. Our proposal would make that possible."

Fuel consumption in areas warmed by local heating centers with heat pumps could decrease by 30 to 40 percent. The heat pumps would be fuel powered, for example using diesel, not powered by electricity. The oil-burning boilers already installed in the local heating centers could be retained for occasions with extra high heat consumption.

But, one might object, such heat pumps are not yet available, nor are there any examples of solar heating systems of this size. Kjell Wanselius says:

"No, but the technology is not unknown. And I am a firm believer in technological development. What is needed to carry out our proposal is (political) will power.

Key:

1. Fixed costs
2. Mobile costs
3. Local oil heating
4. Local natural gas heating
5. Remote oil heating
6. Remote coal heating
7. Electric Heating from nuclear power

Costs for various types of heating in Stockholm, expressed in ore per kilowatt-hour. Types of energy with high mobile costs open the door for later introduction of alternate kinds of energy.

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NEW ETHANOL PROCESS SAVES 60 PERCENT ENERGY

Stockholm NY TEKNIK in Swedish 7 Feb 80 p 5

[Article by Sverker Nyman]

[Text] Statens Industriverk is investing almost 1.5 million kronor in a new ethanol distilling process that has been produced by Sorigona. The novelty of the method is that it is possible to restore part of the energy expended in the distilling process. The energy savings will be 60 percent.

In conventional ethanol distilling, the mash is boiled and the ethanol vapor is cooled to be condensed. The heat supplied to the vapor is lost in cooling.

In the Sorigona method, the temperature of the alcohol vapor is raised in a thermocompressor. Under the higher pressure, the alcohol condenses at 115-120 °C and is removed from the process. The remainder is brought under the boiling vessel to contribute toward heating. The vessels are often heated with steam and with this system the steam requirements are reduced 30 percent.

The thermocompressor is electrically powered, so the total energy savings are estimated at around 60 percent.

Industriverket's subsidy will be used to build a functioning facility at the company's plant in Staffanstorp, where there is a recovery facility for alcohol that has been used in chemical processes. If it turns out that the facility operates well, the method will be used at Svenska Sockerfabrik AB's future facility in Karpalund.

The intention is to produce ethanol there from sugar beets. According to plans, beginning in 1983 the facility will produce 190 tons of ethanol per day.

"The next step may be for us to produce methane gas from the leftover mash," says Harald Skogman at Sorigona. "Then the process will be completely energy self-sufficient, not including the ethanol's energy content."

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NO MONEY FROM STATE FOR NEW IRON PROCESSES

Stockholm NY TEKNIK in Swedish 7 Feb 80 p 3

[Article by Anders Sundberg]

[Text] There will be no prototype plant in Sweden for any of the three newly developed pig-iron processes. In the foreseeable future, there is no possibility of carrying out such a project.

Last Thursday, SKF Steel requested 90 million kronor from the state to start a so-called half-scale plant and further develop its new pig-iron process--the plasma method.

The preceding week, Industry Minister Nils G. Asling had revealed in an interview with NY TEKNIK: "There is at present no economic possibility of starting prototype plants for any of the three pig-iron methods--SKF's plasma method, Boliden's "inred," and Asea and Stora Kopparberg's "elred"--developed by SKF, Boliden, and Asea, together with Stora Kopparberg.

These reports were confirmed by the Industry Department at the end of last week. Anders Davidsson, information secretary at the department said:

"At present, it is not economically feasible for the state to go in and pay for construction of a prototype plant."

Overall, the situation is very tight on the steel market and SSAB has its pig-iron needs met for the next few years.

May Have To Move Abroad

Bjorn Jonson, director of information at SKF Steel says:

"If we do not receive the money we have requested, 60 million kronor to construct a half-scale plant and 30 million for further development of the plasma method, we will have to look abroad."

"We must not lose the head start we have on our competitors abroad. We should have an answer from the Industry Department before the end of the second quarter."

"SKF's Move Appears Desparate"

"Inred" is Boliden's new melt-reduction process. It is one of the three methods fighting for state subsidies.

"SKF's move seems a little desparate," says Hans Elfvander, chief engineer at Boliden Kemi.

"We are still evaluating our method using our own experts and consultants. We are keeping the state continuously informed of developments."

"We hope it will be possible to construct a plant of medium size for long-term demonstration."

Hans Stickler, director of Stora Kopparberg and Asea's joint company for developing the third pig-iron process, Elred, says:

"We want to erect a full-scale plant directly. Other alternatives are too expensive."

"Our research is complete. The results will be presented this spring. We estimate the costs to be around 500 million kronor, costs we are prepared to pay in part ourselves."

"If we are unable to finance the project in Sweden, we may be forced to go abroad, to Japan for example. And to attract a foreign company into so large a project, we may be forced to sell our patent," Hans Stickler continues.

"The greatest risk is that our foreign competitors will catch up to us."

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NEW GAS TURBINE ENGINE MORE FUEL-EFFICIENT THAN DIESELS

Stockholm SVENSKA DAGBLADET in Swedish 22 Mar 80 p 4

[Article by Hans Rehnvall]

[Text] Asea, together with the Volvo affiliate United Turbine, has made a technical breakthrough that can make the gas turbine engine competitive in passenger cars--and it can create a new Swedish industry worth billions.

Since 1977, Asea and United Turbine (which is located in Malmo) have been working together to produce a turbine wheel made of ceramic material that can be used in gas turbines. The gas turbine, which has previously been uncompetitive because it has used too much fuel, is presently viewed by international opinion as the most promising alternative to the conventional gasoline engine and the diesel.

1,700 Degrees

For many years, Asea's high-pressure laboratory in Robertsfors has been experimenting with parts made of silicon nitride. A powder of the substance is pressed together--the pressure is 2,000 atmospheres and the temperature around 1,700 degrees. It is this process that has been shown to work in industrial production--with all the precision required of a turbine wheel, which must turn at over 50,000 revolutions per minute.

The factor that determines a gas turbine's efficiency is how high a temperature it can withstand during operation--and to achieve the high temperatures required to make it better than the diesel, many parts, including turbine wheels, must be made of ceramic material capable of withstanding nearly 1,500 °C.

First, the turbine wheel is pressed using silicon nitride powder. Then the wheel is covered with pulverized glass and placed in a high-pressure press. The glass melts and forms a tight outer surface that presses the powder inside together until it becomes a very dense body.

A similar pressing technique is used for aluminum oxide capsules that can be used to store high-level radioactive waste.

The complete, pressed turbine wheel is smaller than the original. The difficulty, among other things, has been to produce parts with sufficient precision.

No Gearbox

The director of United Turbine, which is owned by Volvo, is Prof Sven-Olov Kronogard. He has constructed a gas turbine for passenger cars that operates without a gearbox--the turbine itself acts as an automatic transmission--and that even with present-day material can compete with conventional automobile motors.

"This is a very significant advance," he says. "The new ceramics, together with the breakthrough of our gas turbine, may mean that Sweden will be the first to have a functioning automobile gas turbine using ceramic material."

Volvo has contacted the industrial fund to obtain the possibility of increasing its efforts in the area of turbines. Both Asea's process and United Turbine's design are well covered by patents--and if the project remains in Sweden it can develop into an industry worth billions.

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